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Evaluation of Increasing Dietary Threonine to Lysine Ratio in Corn Soybean Meal Diets with and without DDGS on Growth Performance and Carcass Characteristics of Growing-Finishing Pigs

Andres F. Tolosa
Kansas State University, atolosa@ksu.edu

Mike D. Tokach
Kansas State University, mtokach@k-state.edu

Robert D. Goodband
Kansas State University, goodband@ksu.edu

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Abstract

A total of 2,160 pigs (PIC 337 × 1050; initial BW 77.3 lb) were used in a 112-d growth trial to evaluate the effects of normal or high SID Thr:Lys ratio in diets with and without DDGS on growth performance. Pigs were randomly assigned to pens (27 pigs per pen) in a randomized complete block design by BW with 20 replications per treatment. Pens of pigs were allotted to 1 of 4 dietary treatments arranged in a 2 × 2 factorial with main effects of dietary Thr level (Normal vs. High) and DDGS (with or without DDGS). Treatment diets were formulated in 4 phases from 75 to 125, 125 to 175, 175 to 230, and 230 to 300 lb BW. Diets with high DDGS were formulated to include 40% DDGS in phase 1 and 2, 30% in phase 3, and 15% in phase 4. Normal Thr diets were formulated to contain 61, 62, 63, and 65% SID Thr:Lys ratios for the four dietary phases, respectively. High Thr diets had SID Thr:Lys ratios of 67, 68, 69, and 72%, respectively. There were no interactions ($P > 0.10$) observed in any phase or overall, between Thr level and inclusion of DDGS for ADG, ADFI, F/G, and BW. For the overall period (d 0 to 112), pigs fed diets without DDGS had increased ($P < 0.001$) ADG and BW and reduced ($P < 0.001$) ADFI leading to improved ($P < 0.001$) F/G. There was no evidence for difference ($P > 0.10$) between diets with or without the inclusion of DDGS when diets were formulated to normal or high SID Thr:Lys ratio. In summary, the addition of high levels of DDGS reduced ADG and increased ADFI, which resulted in poorer F/G and lower final BW, regardless of the dietary SID Thr:Lys level. Additional research should be conducted to evaluate the effect of high Thr:Lys levels when soluble fiber sources are included in finishing pig diets instead of an insoluble fiber source such as corn DDGS.

Keywords

finishing pig, growth, DDGS, threonine

Cover Page Footnote

The authors appreciate New Horizon Farms, Pipestone, MN, for providing technical assistance for these studies.

Authors

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SWINE DAY 2021

Evaluation of Increasing Dietary Threonine to Lysine Ratio in Corn Soybean Meal Diets with and without DDGS on Growth Performance and Carcass Characteristics of Growing-Finishing Pigs[1]

Andres F. Tolosa, Mike D. Tokach, Robert D. Goodband, Jason C. Woodworth, Joel M. DeRouchey, and Jordan T. Gebhardt[2]

Summary

A total of 2,160 pigs (PIC 337 × 1050; initial BW 77.3 lb) were used in a 112-d growth trial to evaluate the effects of normal or high SID Thr:Lys ratio in diets with and without DDGS on growth performance. Pigs were randomly assigned to pens (27 pigs per pen) in a randomized complete block design by BW with 20 replications per treatment. Pens of pigs were allotted to 1 of 4 dietary treatments arranged in a 2 × 2 factorial with main effects of dietary Thr level (Normal vs. High) and DDGS (with or without DDGS). Treatment diets were formulated in 4 phases from 75 to 125, 125 to 175, 175 to 230, and 230 to 300 lb BW. Diets with high DDGS were formulated to include 40% DDGS in phase 1 and 2, 30% in phase 3, and 15% in phase 4. Normal Thr diets were formulated to contain 61, 62, 63, and 65% SID Thr:Lys ratios for the four dietary phases, respectively. High Thr diets had SID Thr:Lys ratios of 67, 68, 69, and 72%, respectively. There were no interactions ($P > 0.10$) observed in any phase or overall, between Thr level and inclusion of DDGS for ADG, ADFI, F/G, and BW. For the overall period (d 0 to 112), pigs fed diets without DDGS had increased ($P < 0.001$) ADG and BW and reduced ($P < 0.001$) ADFI leading to improved ($P < 0.001$) F/G. There was no evidence for difference (P > 0.10) between diets with or without the inclusion of DDGS when diets were formulated to normal or high SID Thr:Lys ratio. In summary, the addition of high levels of DDGS reduced ADG and increased ADFI, which resulted in poorer F/G and lower final BW, regardless of the dietary SID Thr:Lys level. Additional research should be conducted to evaluate the effect of high Thr:Lys levels when soluble fiber sources are included in finishing pig diets instead of an insoluble fiber source such as corn DDGS.

[1] The authors appreciate New Horizon Farms, Pipestone, MN, for providing technical assistance for these studies.

[2] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

Introduction

Threonine is an essential amino acid for pigs. Mucus in the gastrointestinal tract has a high concentration of Thr. Dietary fiber increases endogenous protein losses by increasing sloughing of intestinal mucosal cells, increasing mucus production, and making the Thr requirement for maintenance relatively high.[3] Consequently, pigs fed high fiber diets could require an increase in the SID Thr:Lys ratio in the diet. Therefore, the objective of this study was to determine if an increased Thr:Lys ratio is required to optimize growth performance when DDGS is included in the diet of grow-finish pigs.

Materials and Methods

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. This experiment was conducted in two barns at a commercial research grow-finishing site in southwest Minnesota (New Horizon Farms, Pipestone, MN). Each barn was naturally ventilated and double-curtain-sided with a slatted concrete floor and deep manure storage. Each pen (10 × 18 ft) was equipped with a 5-hole stainless steel dry self-feeder (Thorp Equipment, Thorp, WI) and a cup waterer for *ad libitum* access to feed and water. The facility was equipped with a computerized feeding system (FeedPro; Feedlogic Corp., Willmar, MN) that delivered and recorded daily feed additions.

Animals and diets

Two groups of 1,080 pigs (2,160 total pigs; PIC 337 × 1050; initial BW 77.3 ± 1.04 lb) were used in a 112-d growth trial. Pens of pigs (27 pigs per pen) were randomly assigned to 1 of 4 dietary treatments in a randomized complete block design with BW serving as the blocking factor resulting in 20 observations (pens) per treatment. Dietary treatments were arranged in a 2 × 2 factorial with main effects of SID Thr:Lys ratio (Normal vs. High) and DDGS (with or without DDGS). Diets were fed in 4 phases from 75 to 125, 125 to 175, 175 to 230, and 230 to 300 lb body weight (Table 1). Diets with DDGS were formulated to include 40% DDGS in phase 1 and 2, 30% in phase 3, and 15% in phase 4. Normal Thr diets were formulated to contain SID Thr:Lys ratios of 61, 62, 63, and 65%, and the high Thr diets had SID Thr:Lys ratios of 67, 68, 69 and 72%, for the four dietary phases, respectively. All treatment diets were manufactured at New Horizon Farms Feed Mill in Pipestone, MN, and were formulated to meet or exceed NRC[4] requirement estimates for growing-finishing pigs for their respective weight ranges (Table 1 and 2).

Pens of pigs were weighed, and feed disappearance was determined every 2 weeks to determine ADG, ADFI, and F/G. Two weeks before the end of the experiment, 3 pigs per pen were removed and marketed. The remaining pigs in the pen were weighed and marketed at the completion of the experiment. No carcass data were collected because of packing plant COVID-19 restrictions.

[3] Schulze H, P. van Leeuwen, M. W. A. Verstegen, J. Huisman, W. B. Souffrant and F. Ahrens. 1994. Effect of level of neutral detergent fiber on ileal apparent digestibility and ileal nitrogen losses in pigs. J. Anim. Sci. 72:2362–2368.

[4] National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298.

Statistical analysis

Pens of pigs were the experimental units for all data. Data were analyzed using the nlme package of R (Version 4.0.0, R Foundation for Statistical Computing, Vienna, Austria) as a randomized complete block design with body weight as the blocking factor and pen as the experimental unit. The main effects and interactions of DDGS and Thr level were tested. Model assumptions were checked and considered to be appropriately met. Differences between treatments were considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

Results and Discussion

There were no interactions observed between SID Thr:Lys ratio and DDGS for any response criteria (Table 3). Furthermore, no differences were detected ($P > 0.10$) for ADG, ADFI, F/G or BW for pigs fed diets with normal Thr levels compared to pigs fed high Thr throughout the study.

From d 0 to 28, pigs fed diets without DDGS had increased ($P < 0.001$) ADG, d 28 BW and improved ($P < 0.001$) F/G, with no evidence of difference ($P > 0.10$) in ADFI compared to pigs fed DDGS (Table 4). From d 28 to 56, pigs fed without DDGS had increased ($P < 0.001$) ADG and BW, and decreased ($P < 0.012$) ADFI that resulted in improved ($P < 0.001$) F/G compared to those pigs fed high DDGS.

From d 56 to 84, no evidence of difference was observed for ADG ($P > 0.10$) between pigs fed diets with or without DDGS, but pigs fed diets without DDGS had reduced ($P < 0.001$) ADFI and improved ($P < 0.001$) F/G compared with pigs fed DDGS. Interestingly, from d 84 to 112, pigs fed DDGS in the diet had increased ($P < 0.001$) ADG compared with pigs fed diets without DDGS, which could be explained by the reduction in the level of DDGS from 40 to 30 and 15% in the third and fourth dietary phase, respectively. However, pigs fed diets without DDGS had decreased ($P < 0.001$) ADFI with no evidence of difference ($P > 0.10$) in F/G between DDGS treatments. Overall (d 0 to 112), pigs fed diets without DDGS had increased ($P < 0.001$) ADG and BW, reduced ($P < 0.001$) ADFI, and improved ($P < 0.001$) F/G compared with pigs that were fed DDGS.

In summary, pigs fed diets with DDGS had decreased ADG, higher ADFI, and poorer F/G, resulting in 7.1 lb lower final body weight compared to pigs without DDGS in the diet. Increasing SID Thr:Lys ratio above pigs' requirement in this experiment did not improve final BW or overall growth performance. The results of this study suggest that feeding diets with high levels of DDGS decrease the overall growth performance with no ameliorating effect of increasing Thr in the diet. A potential reason could be that DDGS is an insoluble fiber source, different results might occur if a soluble fiber source is provided.

Table 1. Composition of phase 1 and 2 diets (as-fed basis)[1]

	Phase 1				Phase 2			
	No DDGS		DDGS		No DDGS		DDGS	
Item	Normal Thr	High Thr	Normal Thr	High Thr	Normal Thr	High Thr	Normal Thr	High Thr
Ingredients, %								
Corn	72.67	72.60	50.34	50.27	78.90	78.84	55.75	55.70
Soybean meal	24.64	24.65	6.82	6.82	18.51	18.51	1.49	1.49
Corn DDGS	---	---	40.00	40.00	---	---	40.00	40.00
Limestone	0.95	0.95	1.35	1.35	0.95	0.95	1.35	1.35
Monocalcium P (21% P)	0.60	0.60	---	---	0.55	0.55	---	---
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
L-Lys-HCl	0.30	0.30	0.60	0.60	0.30	0.30	0.58	0.58
DL-Met	0.08	0.08	0.03	0.03	0.05	0.05	---	---
L-Thr	0.08	0.14	0.12	0.19	0.08	0.13	0.11	0.17
L-Trp	0.01	0.01	0.07	0.07	0.02	0.02	0.07	0.07
Mineral-vitamin premix	0.15	0.15	0.15	0.15	0.13	0.13	0.13	0.13
Phytase[2]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Total	100	100	100	100	100	100	100	100
Calculated analysis								
Standardized ileal digestible (SID) amino acids, %								
Lys	1.02	1.02	1.02	1.02	0.87	0.87	0.87	0.87
Ile:Lys	62	62	55	55	61	61	55	55
Leu:Lys	136	136	169	169	144	143	184	184
Met:Lys	33	33	32	32	32	32	32	32
Met and Cys:Lys	58	58	58	58	58	58	60	60
Thr:Lys	61	67	61	67	62	68	62	68
Trp:Lys	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1
Val:Lys	69	69	69	69	70	70	71	71
SID Lys:NE, g/Mcal	4.13	4.13	4.14	4.14	3.47	3.47	3.49	3.49
NE, kcal/lb	1,121	1,121	1,116	1,116	1,138	1,138	1,130	1,131
CP, %	18.14	18.19	19.39	19.43	15.72	15.76	17.25	17.28
Ca, %	0.58	0.58	0.61	0.61	0.55	0.55	0.59	0.59
P, %	0.49	0.49	0.47	0.47	0.46	0.45	0.45	0.45
STTD P, %	0.26	0.26	0.26	0.26	0.24	0.24	0.24	0.24

[1]Phases 1 and 2 were fed from 75 to 125, and 125 to 175 lb, respectively.
[2]Optiphos 2000 (Huvepharma Inc., Peachtree City, GA) provided 389.6 units of phytase FTU/lb of diet with an assumed release of 0.11% STTD P.

Table 2. Composition of phase 3 and 4 diets (as-fed basis)[1]

	Phase 3				Phase 4			
	No DDGS		DDGS		No DDGS		DDGS	
Item	Normal Thr	High Thr	Normal Thr	High Thr	Normal Thr	High Thr	Normal Thr	High Thr
Ingredients, %								
Corn	83.54	83.49	66.02	65.97	85.82	85.77	77.09	77.04
Soybean meal	14.01	14.01	1.44	1.45	11.95	11.95	5.67	5.67
Corn DDGS	---	---	30.00	30.00	---	---	15.00	15.00
Limestone	0.95	0.95	1.25	1.25	0.90	0.90	1.05	1.05
Monocalcium P (21% P)	0.45	0.45	---	---	0.25	0.25	---	---
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
L-Lys-HCl	0.30	0.30	0.50	0.50	0.30	0.30	0.40	0.40
DL-Met	0.03	0.03	---	---	0.02	0.02	---	---
L-Thr	0.08	0.13	0.10	0.15	0.09	0.14	0.10	0.15
L-Trp	0.02	0.02	0.06	0.06	0.02	0.02	0.04	0.04
Mineral-vitamin premix	0.10	0.10	0.10	0.10	0.08	0.08	0.08	0.08
Phytase[2]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Total	100	100	100	100	100	100	100	100
Calculated analysis								
Standardized ileal digestible (SID) amino acids, %								
Lys	0.76	0.76	0.76	0.76	0.71	0.71	0.71	0.71
Ile:Lys	60	60	55	55	60	60	57	57
Leu:Lys	151	150	186	186	155	155	173	173
Met:Lys	31	31	32	32	30	30	31	31
Met and Cys:Lys	58	58	62	62	58	58	60	60
Thr:Lys	63	69	63	69	65	72	65	72
Trp:Lys	19.2	19.2	19.1	19.1	19.0	19.0	19.1	19.1
Val:Lys	70	70	72	72	70	70	71	71
SID Lys:NE, g/Mcal	2.99	2.99	3.01	3.01	2.78	2.78	2.78	2.78
NE, kcal/lb	1152	1152	1146	1146	1160	1160	1157	1157
CP, %	13.94	13.98	15.17	15.20	13.15	13.19	13.76	13.80
Ca, %	0.52	0.52	0.54	0.54	0.45	0.45	0.46	0.46
P, %	0.41	0.41	0.40	0.40	0.36	0.36	0.35	0.35
STTD P, %	0.21	0.21	0.21	0.21	0.16	0.16	0.16	0.16

[1]Phases 3 and 4 were fed from 175 to 230, and 230 to 300 lb, respectively.
[2]Optiphos 2000 (Huvepharma Inc., Peachtree City, GA) provided 389.6 units of phytase FTU/lb of diet with an assumed release of 0.11% STTD P.

Table 3. Interactive effects of DDGS and Thr on grow-finish pig performance[1]

	No DDGS		DDGS[2]			*P* =		
Item	Normal Thr[3]	High Thr[4]	Normal Thr[3]	High Thr[4]	SEM	Thr	DDGS	Thr × DDGS
Initial BW, lb								
d 0	77.4	77.4	77.3	76.9	1.04	0.547	0.291	0.362
d 28	128.8	129.0	124.9	123.4	1.33	0.360	< 0.001	0.187
d 56	185.3	186.9	178.4	177.5	1.47	0.707	< 0.001	0.205
d 84	242.3	243.3	234.9	233.9	1.98	0.967	< 0.001	0.397
d 112	300.8	301.8	294.5	293.9	1.78	0.919	< 0.001	0.612
Day 0 to 28								
ADG, lb	1.80	1.80	1.67	1.63	0.037	0.278	< 0.001	0.319
ADFI, lb	3.87	3.96	3.99	3.90	0.059	0.955	0.574	0.070
F/G	2.16	2.21	2.40	2.40	0.038	0.318	< 0.001	0.362
Day 28 to 56								
ADG, lb	2.18	2.20	2.05	2.09	0.022	0.252	< 0.001	0.663
ADFI, lb	5.47	5.58	5.71	5.69	0.080	0.461	0.012	0.347
F/G	2.51	2.54	2.78	2.73	0.030	0.791	< 0.001	0.124
Day 56 to 84								
ADG, lb	2.02	2.00	2.02	2.00	0.062	0.354	0.964	0.903
ADFI, lb	6.23	6.33	6.59	6.57	0.139	0.509	< 0.001	0.311
F/G	3.11	3.19	3.28	3.32	0.055	0.182	< 0.001	0.632
Day 84 to 112								
ADG, lb	2.16	2.15	2.22	2.26	0.033	0.563	0.009	0.559
ADFI, lb	7.56	7.63	7.99	8.00	0.097	0.649	< 0.001	0.792
F/G	3.52	3.55	3.61	3.54	0.059	0.734	0.411	0.370
Day 0 to 112								
ADG, lb	2.03	2.03	1.98	1.98	0.012	0.996	< 0.001	0.966
ADFI, lb	5.72	5.81	5.99	5.96	0.059	0.573	< 0.001	0.266
F/G	2.82	2.86	3.03	3.01	0.027	0.527	< 0.001	0.188

[1]A total of 2,160 pigs were used in two groups with 27 pigs per pen and 20 replicates per treatment. Phase 1 was fed from day 0 to 28, phase 2 from day 28 to 56, phase 3 from day 56 to 84, and phase 4 from day 84 to 112.
[2]DDGS included at 40% in phase 1 and 2, 30% in phase 3 and 15% in phase 4.
[3]SID Thr:Lys were 61, 62, 63, and 65 in phase 1, 2, 3, and 4, respectively.
[4]SID Thr:Lys were 67, 68, 69, and 72 in phase 1, 2, 3, and 4, respectively.

Table 4. Main effects of DDGS and Thr on grow-finish pig performance[1]

	DDGS[2]				Thr			
	No DDGS	High DDGS	SEM	*P* =	Normal Thr[3]	High Thr[4]	SEM	*P* =
Initial BW, lb								
d 0	77.4	77.1	1.02	0.291	77.3	77.2	1.02	0.547
d 28	128.9	124.2	1.23	< 0.001	126.8	126.2	1.24	0.360
d 56	186.1	177.9	1.30	< 0.001	181.8	182.2	1.30	0.707
d 84	242.8	234.5	1.78	< 0.001	238.6	238.6	1.78	0.967
d 112	301.3	294.2	1.41	< 0.001	297.7	297.8	1.40	0.919
Day 0 to 28								
ADG, lb	1.80	1.65	0.034	< 0.001	1.74	1.71	0.033	0.278
ADFI, lb	3.92	3.94	0.049	0.574	3.93	3.93	0.049	0.955
F/G	2.18	2.40	0.032	< 0.001	2.28	2.31	0.032	0.318
Day 28 to 56								
ADG, lb	2.19	2.07	0.017	< 0.001	2.12	2.14	0.016	0.252
ADFI, lb	5.53	5.70	0.064	0.012	5.59	5.64	0.063	0.461
F/G	2.52	2.76	0.023	< 0.001	2.64	2.64	0.023	0.791
Day 56 to 84								
ADG, lb	2.01	2.01	0.060	0.964	2.02	2.00	0.060	0.354
ADFI, lb	6.28	6.58	0.132	< 0.001	6.41	6.45	0.132	0.509
F/G	3.15	3.30	0.046	< 0.001	3.20	3.25	0.046	0.182
Day 84 to 112								
ADG, lb	2.15	2.24	0.024	0.009	2.19	2.21	0.024	0.563
ADFI, lb	7.60	8.00	0.068	< 0.001	7.78	7.82	0.067	0.649
F/G	3.53	3.58	0.044	0.411	3.57	3.55	0.043	0.734
Day 0 to 112								
ADG, lb	2.03	1.98	0.009	< 0.001	2.01	2.01	0.009	0.996
ADFI, lb	5.76	5.98	0.044	< 0.001	5.86	5.89	0.043	0.573
F/G	2.84	3.02	0.021	< 0.001	2.92	2.94	0.021	0.527

[1]A total of 2,160 pigs were used in two groups with 27 pigs per pen and 20 replicates per treatment. Phase 1 was fed from day 0 to 28, phase 2 from day 28 to 56, phase 3 from day 56 to 84, and phase 4 from day 84 to 112.
[2]DDGS included at 40% in phase 1 and 2, 30% in phase 3 and 15% in phase 4.
[3]SID Thr:Lys were 61, 62, 63, and 65 in phase 1, 2, 3, and 4, respectively.
[4]SID Thr:Lys were 67, 68, 69, and 72 in phase 1, 2, 3, and 4, respectively.